2012 UINTAH BASIN WINTER OZONE & AIR QUALITY STUDY
- Summary of Interim Findings, Ongoing Analyses, and Additional Recommended Research [1]-

August 7, 2012

BACKGROUND

The Uintah Basin is a rural area with widely scattered oil and gas development and where ozone concentrations in excess of the current national air quality standard have been measured during the winter. In the first quarter of 2012, a multi-phased study was begun to identify the emissions sources and the unique photochemical processes that cause elevated winter ozone concentrations, and to identify the most effective strategies to reduce winter ozone. This recent winter study phase included an intensive field campaign consisting of measurements of ozone and ozone precursor concentrations and meteorological conditions throughout the Uintah Basin.

This important work is made possible by funding and in-kind support from the following: Uintah Impact Mitigation Special Service District (UIMSSD), Western Energy Alliance, Bureau of Land Management (BLM), National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), National Science Foundation (NSF), and the State of Utah. The work was conducted by researchers from Utah State University/Energy Dynamics Laboratory (USU/EDL); NOAA; Utah Department of Environmental Quality (UDEQ); University of Colorado, Boulder (CU); University of California, Los Angeles (UCLA); University of Wyoming (U of WY); Colorado State University (CSU); University of Washington (UW); and University of California, Berkeley (UC Berkeley).

Presented here are interim findings to this multi-phase study. They are drawn from preliminary analyses of data and results. These interim findings will be updated as the first phase of reports are prepared (planned for October 2012); and after peer-reviewed papers are published and additional research is completed.

INTERIM FINDINGS

The winter 2012 measurements indicate:

- No exceedance of the 75 parts per billion (ppb) National Ambient Air Quality Standard (NAAQS) for ozone was observed. This winter lacked the snow cover and strong inversions with low boundary layer heights that are required for the formation of excessive winter ozone concentrations. The highest 8-hour average ozone concentration observed at the surface during the study period was 62 ppb.

---

[1] Oversight Committee: Managers from Western Energy Alliance, EPA, State of Utah, BLM and Uintah Impact Mitigation Special Service District
Technical Committee: Researchers from USU/EDL, NOAA, CU, U of WY, Alpine Geophysics, ENVIRON, UDEQ and EPA

- Local photochemistry made only small contributions to ozone formation, as evidenced by the quantification of radical sources and chemical processing of oxides of nitrogen (NO_x) and volatile organic compounds (VOC).
- Stratospheric intrusion of ozone was not observed to cause increased ozone concentrations at the surface or in the boundary layer during the 2012 study, however, the lack of high ozone episodes during the study prevents the evaluation of possible stratospheric intrusions during meteorological conditions that cause high ozone levels. Additional study is needed to determine if stratospheric intrusion contributes to surface ozone during winter ozone episodes.
- Observed levels of ambient VOC species were highest in gas-production areas, lower in oil-production areas, and lower still in population centers. Examples of VOC sources include oil and gas production, and on- and off-road vehicles.
- Observed VOC and methane concentrations at the Horse Pool monitoring station (located in a gas-production area) were higher than those typically observed in U.S. urban areas. The mix of VOC observed in the Uintah basin has a higher proportion of alkanes. These alkanes have lower reactivity for ozone formation as compared to the highly reactive alkenes found in typical urban mixtures. However, the higher VOC concentrations present in the Uintah Basin make the total reactivity about the same as found in an urban area. This is meaningful because the reactivity of the VOC mixture can affect the optimal ozone control strategy, and it may be possible to reduce ozone levels more effectively by identifying targeted control strategies for high reactivity VOC, such as aromatic, aldehyde and alkene species.
- The highest NO_x concentrations were observed in the Basin's population centers (i.e., Vernal and Roosevelt); concentrations were lower in gas-production areas, and lower still in oil-production areas. Examples of NO_x sources include on- and off-road motorized vehicles, O&G production equipment, and coal-burning power plants.
- Methanol, a source of primary and secondary formaldehyde (an important ozone precursor), was observed in concentrations that could significantly contribute to ozone formation in the Uintah Basin.

ONGOING ANALYSES

Additional work is in progress using data from the 2012 study, and these results will be reported in the Phase 1 study report in October, 2012. Additional analysis still underway includes the following topics:

- Winter climatology analyses that characterize the meteorological conditions that increase winter ozone formation (USU/EDL effort).
- Estimates of VOC and NO_x emissions for specific source types and refined total-Basin estimates of VOC and NO_x emissions (USU/EDL effort; the BLM ARMS emissions study is also a valuable resource for this effort). Emissions data will support ozone modeling studies.
- VOC reactivity estimates that use hydroxyl radical (OH) rate constants and maximum incremental reactivity procedures (NOAA effort). The reactivity data is needed to model local ozone formation and to evaluate the sensitivity of ozone to VOC and NO_x mitigation.
- Quantification of emission speciation profiles (using NOAA's Mobile Laboratory data) for various NO_x and VOC point sources in the oil and gas field. Data from the NOAA light aircraft effort will also be analyzed in the coming months and will be integrated when ready in future flux

calculations for the region. The information gathered by the Mobile Lab will be shared with emission inventory developers to determine if some emission sources may have been underestimated in current bottom-up inventories, including the WRAP 2012 inventory projection.

ADDITIONAL RECOMMENDED RESEARCH

The 2012 winter season did not have persistent snow cover or the winter inversion conditions that are linked to the formation of high winter ozone concentrations. Therefore, the study team was not able to perform measurements of chemistry or the meteorological conditions that cause high ozone in winter. While the data collected in the 2012 study are useful to estimate emissions inventories and to establish baseline conditions, additional measurements are needed to evaluate the sensitivity of winter ozone to VOC and NO_x and to identify the most effective mitigation strategies for reducing winter ozone. Continuing study goals include the following:

1. Characterize spatial variability in ambient ozone, VOC and NO_x concentrations during ozone episodes. This is necessary to evaluate ozone sensitivity to VOC and NO_x in different areas within the basin and to characterize emissions and transport across the basin.

2. Continue development of a basin-wide emissions inventory (temporal and spatial distribution and speciation of VOC and NO_x) that integrates the gridded and activity-specific information of current inventories. There are three categories of emissions inventory development work including:

   A. Bottom up estimates using activity data and equipment emissions factors.

   B. Top down estimates using ambient concentrations and modeling.

   C. Source testing and mass flux modeling to develop new emissions factors for specific sources.

3. Evaluate the importance of snow photochemistry and radical budgets. This addresses the potential for unique aspects of winter ozone chemistry to affect the sensitivity of ozone to VOC and NO_x.

4. Characterize transport of NO_x emissions within and above the inversion layer. Transport of NO_x emissions above the inversion layer will affect VOC and NO_x concentrations within the inversion layer and could change the relative effectiveness of VOC and NO_x emissions mitigation.

5. Make additional meteorological measurements to characterize inversion height and winds. This is necessary for modeling ozone in the basin and for evaluating the transport and dispersion of emissions.

6. Develop photochemical model simulations to evaluate effectiveness of VOC and NOx mitigation. This is needed to quantify the level of VOC or NO_x mitigation.

7. Quantify day specific background ozone levels during high ozone episodes. This is needed to accurately estimate the amount of ozone formed locally in the basin.

8. Evaluate trends in ozone, VOC and NO_x ambient levels over multiple years.

The study team is developing a plan for the winter of 2012-13 to continue to investigate the causes of high winter ozone in the Uintah Basin and to identify the most effective mitigation strategies. It is uncertain if meteorological conditions will be conducive to high ozone levels in winter 2012-2013, therefore, the study plan calls for rapid deployment of additional studies only if there is significant snow on the ground in early January 2013.

**The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the author(s) and do not necessarily reflect the views of NOAA or the Department of Commerce.*

-This Page Intentionally Left Blank -

2012 UINTAH BASIN WINTER OZONE & AIR QUALITY STUDY – Possible Mitigation Strategies –

Prepared by researchers and air quality managers at
USU/EDL, Alpine Geophysics, EVIRON, UDEQ and EPA

Current data is insufficient to answer the level of control that could eventually be required to achieve ozone-reduction objectives. To develop comprehensive recommendations that address specific mitigation needs, measurements that coincide with conditions conducive to ozone formation will be required. Possible mitigation options are identified below as potentially effective strategies.

Ultimately, a validated photochemical model that simulates winter ozone formation will be needed to fully understand and quantify the effectiveness of mitigation strategies, and to tailor an emissions reduction program that is appropriate for the Uintah Basin. This modeling framework will rely on the data collected from studies in the Basin to provide emission inventory inputs, meteorological inputs, boundary conditions, and validation of ozone and precursor concentrations estimated by the model. The research team is initiating this modeling effort. In the meantime, study data is being used to form a conceptual model of how winter ozone is formed and to consider the following possible mitigation options.

POSSIBLE MITIGATION STRATEGIES: VOC

- Reduce emissions from large sources of aromatic VOC (highly reactive with respect to ozone formation). High concentrations of aromatics were observed downwind of a flowback pond.
- Deploy other VOC-reduction strategies such as green completions, low bleed pneumatics, tank and dehydration unit controls, and liquid collection systems controls where economically feasible.

Our best current estimate is that VOC controls will reduce ozone production, but the overall effectiveness of this strategy is currently unknown.

POSSIBLE MITIGATION STRATEGIES: NO_x

- Data collected in the field study suggest that some engines may be operating inefficiently (significant NO_2 emissions were observed). Air quality benefits may be realized via more efficient operation of pump jack engines and other equipment.

Scientific data collected to date are insufficient for assessing the degree to which NO_x reductions will be effective for ozone control.